Memory Technology Directions Platform 2001

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VP Integrated Technology

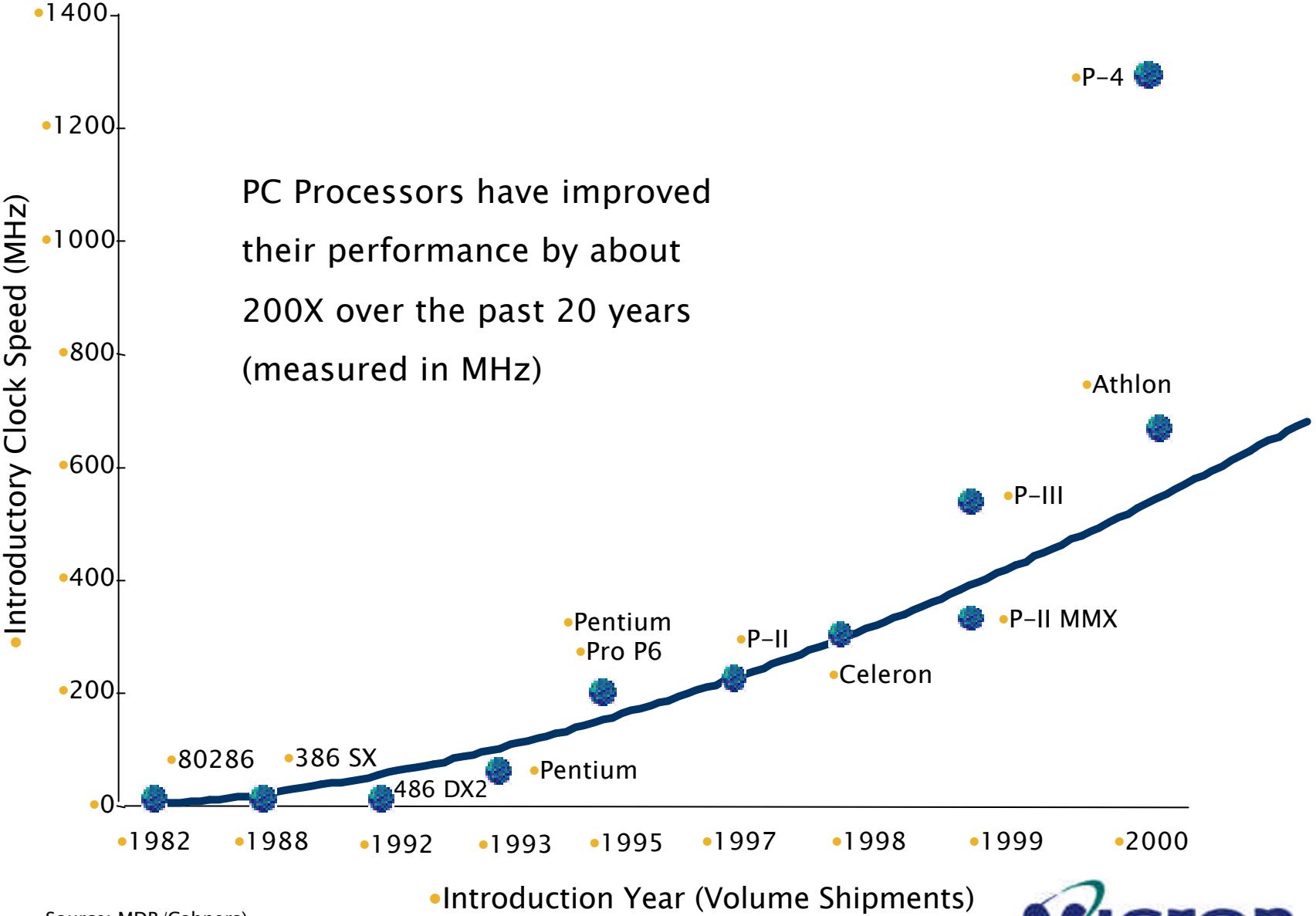
Micron Technology, Inc.

Factors Driving Memory Technology

- Processor business driven by performance
- Memory industry rewarded for integration – process for low leakage, not high speed

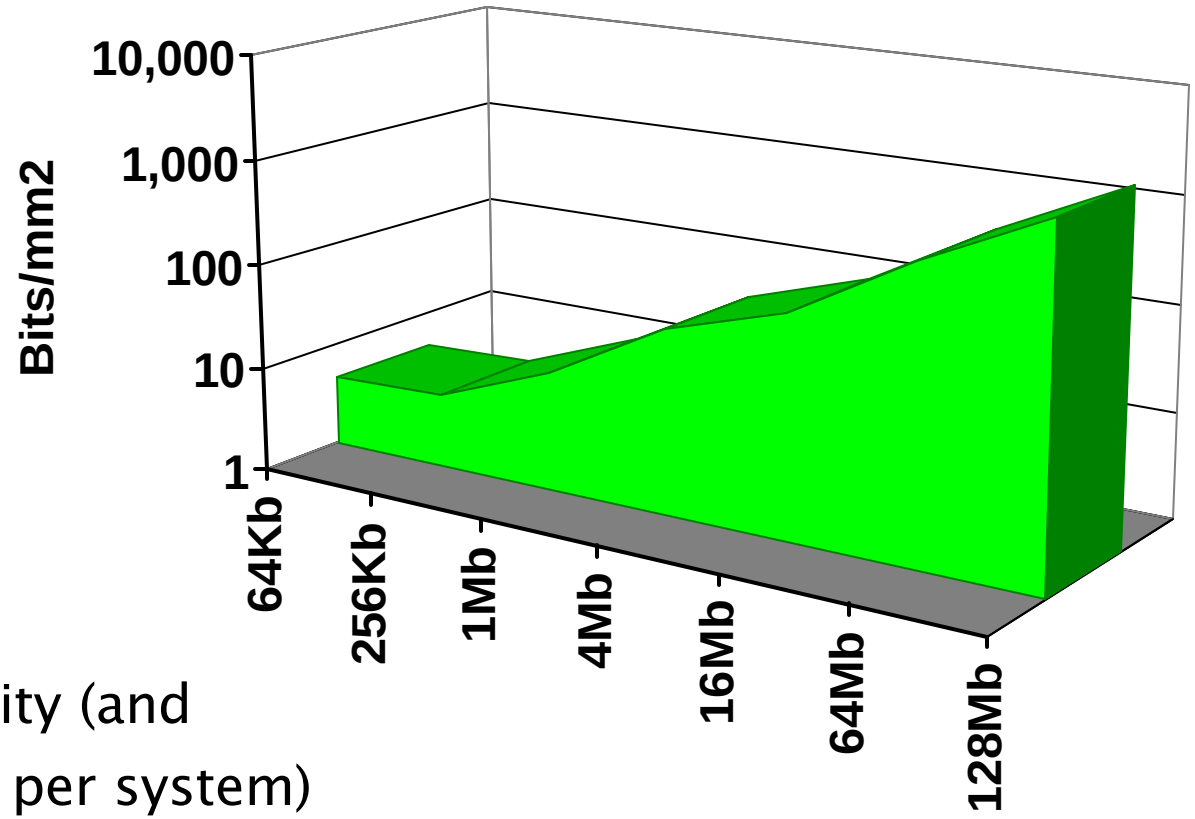
Processor Directions

PC Processors have improved their performance by about 200X over the past 20 years (measured in MHz)



Source: MDR/Cahners)

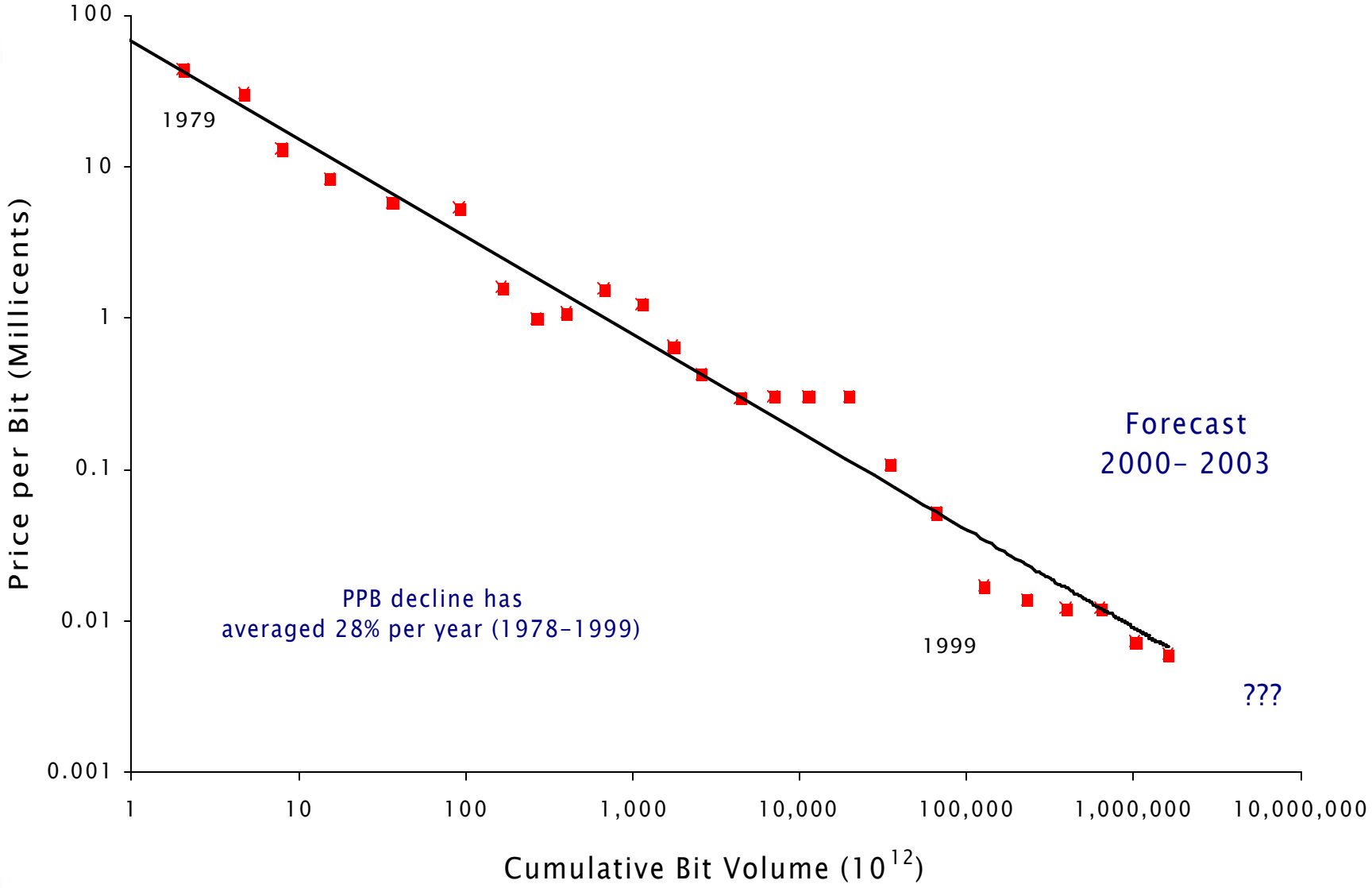
Memory Directions



Memory bit density (and average memory per system) has increased over 2000X in the past 20 years

Source: Micron Technology, Inc.

DRAM Directions



Source: ICE Status '99 1979-1997
Semico Research 08/00, 1998-2003

Emerging Memory

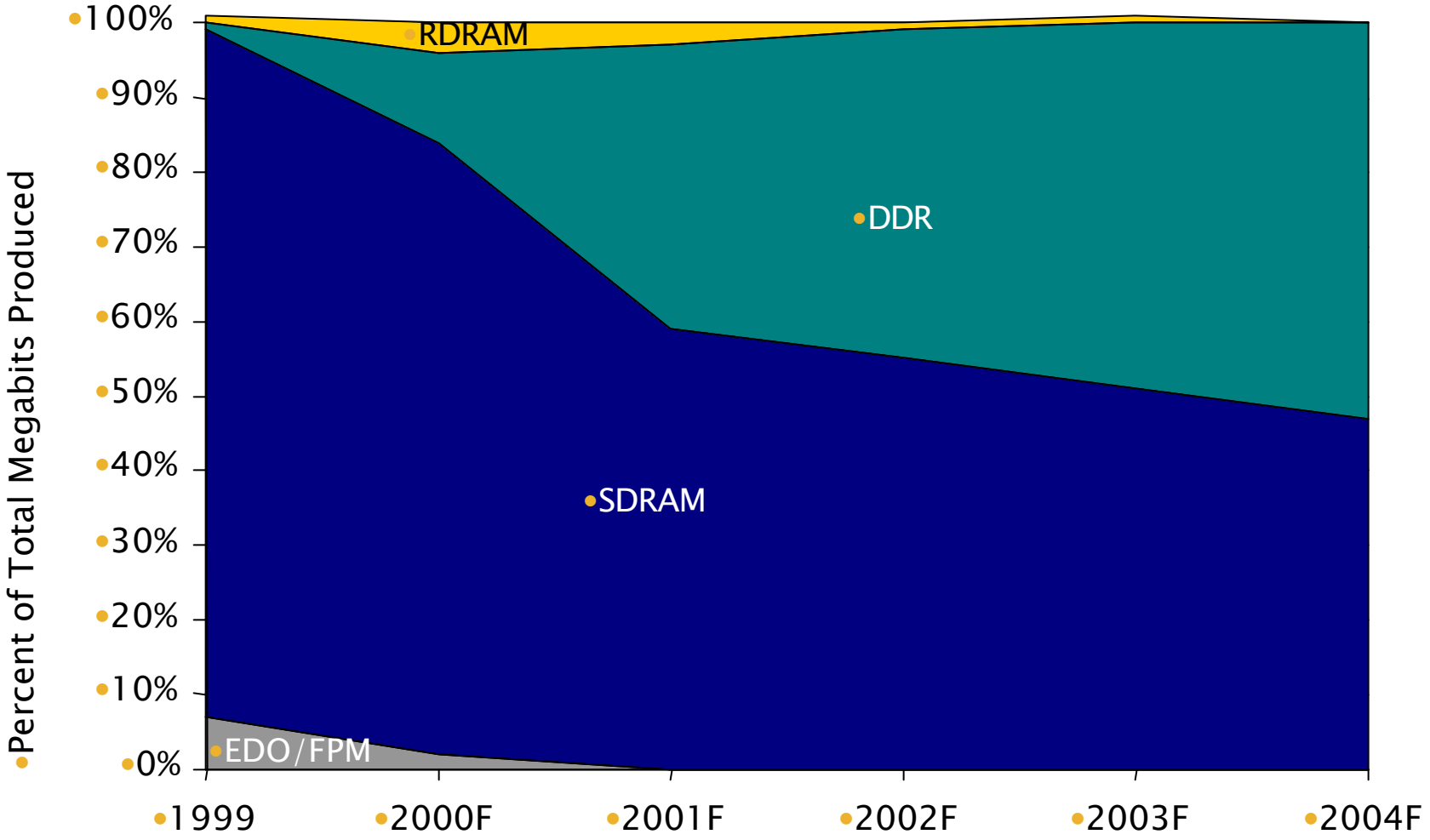
DDR Development

- Component
  - All major DRAM vendors are designing and producing to the JEDEC DDR standard data sheet
- Module
  - JEDEC has defined pinout, block diagram, and SPD
  - AMI2 is coordinating the design on standard common Gerber files for module PCB
    - 184-pin unbuffered and registered DIMM Gerbers are production-ready
    - 200-pin SODIMM Gerbers are ready for 1Q01 production

DDR SDRAM Memory Adoption

- AMD Athlon with 760 demonstrates the power of DDR
- DDR is the memory of choice for new server, workstation, and high-end desktop systems
- DDR as a point-to-point memory subsystem is the memory of choice for fixed-footprint applications

DDR Memory Adoption



Rambus is a registered trademark of Rambus Inc.
Source: Semico Research, 05/00

DDR Adoption Issues

- Misconception: DDR price delta over SDRAM
- Some availability issues
- Core logic solutions
- “Correct by design” PCBs

- Recommendation: DO NOT try mixed DDR/SDR solutions

Future Memory Guidelines

Requirements of a Future Memory Technology

The Challenges:

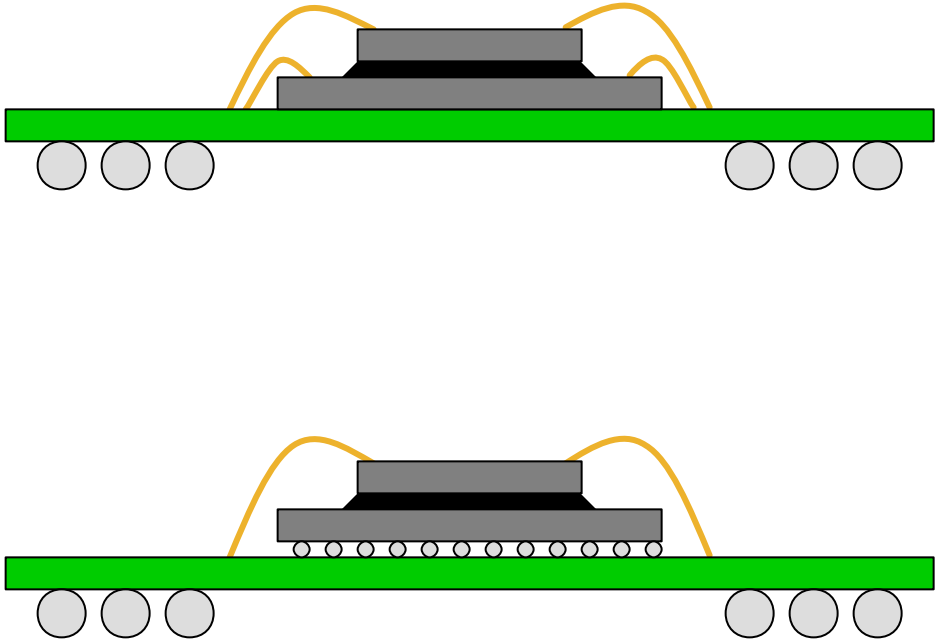
- Add performance – without additional cost
  - No (or minimal) additional component cost
  - No (or minimal) additional system cost
- Solve needs of a wide range of systems
- Keep power and physical form factors in check

System in a Package (SIP)

SIP Directions

- SIP allows multiple technologies in single packages: Logic, DRAM, and Flash
- Ideally, components are designed for SIP
- Required: Known Good Die (KGD)
- Benefits: reduced space, even reduced cost
- Used in portable graphics, cell phones today.

SIP Directions



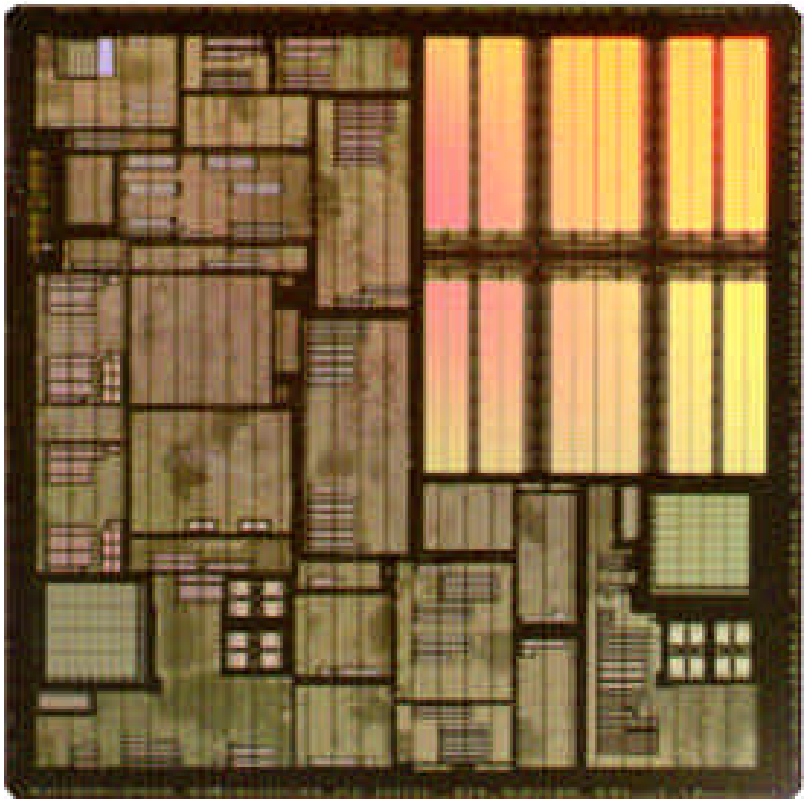
Embedded Memory

- Early applications were in PC Graphics (NeoMagic)
- Today's applications:
  - Peripherals (printers, cameras, HDD)
  - Non-PC computing (WinCE, PalmOS)
  - L3 cache

eDRAM Demonstration and Technology

Micron eDRAM: V4400e Statistics

- The NVIDIA GeForce has 23 Million transistors
- The Intel® P®-III has 28M transistors
- The Intel P-4 has 42M transistors
- V4400: Over 125M transistors!

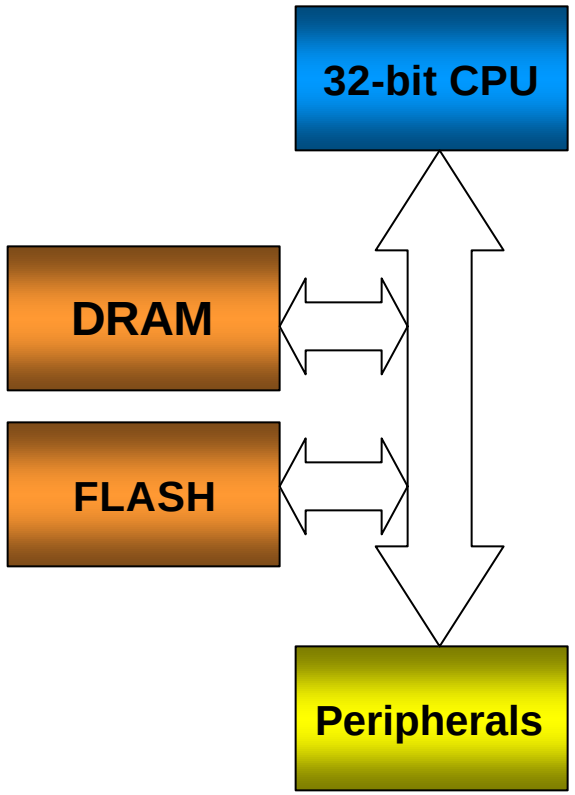


Micron Array Edge

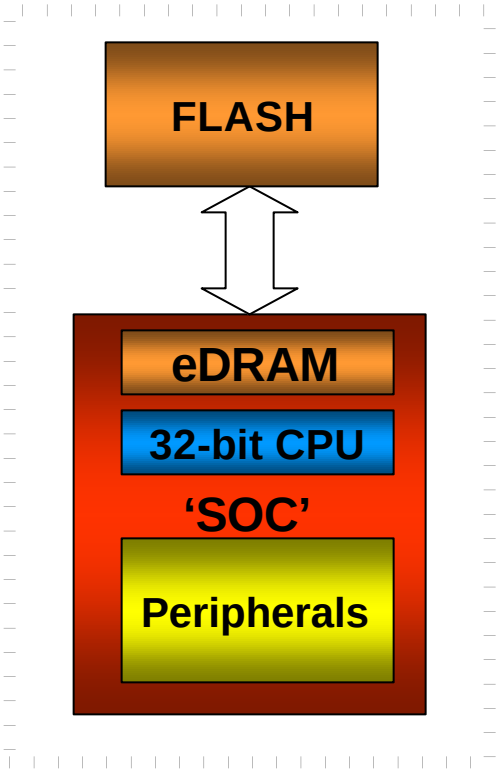
System on a Chip (S.O.C.) with eDRAM

SOC: Repartitioning

- Today:



- Tomorrow:



'SIP' Solutions

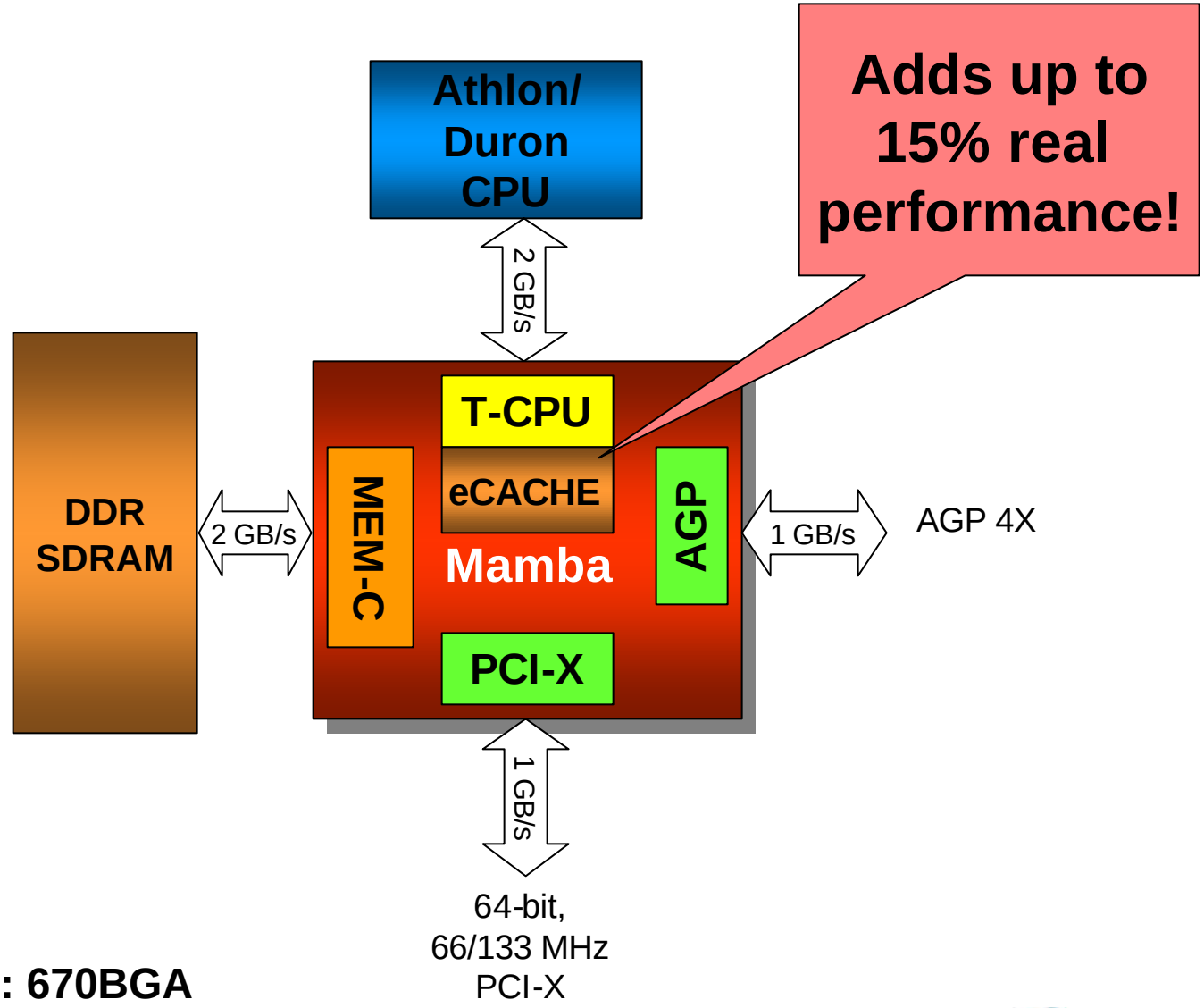
eDRAM L3 Cache

Micron

Current North Bridge Component

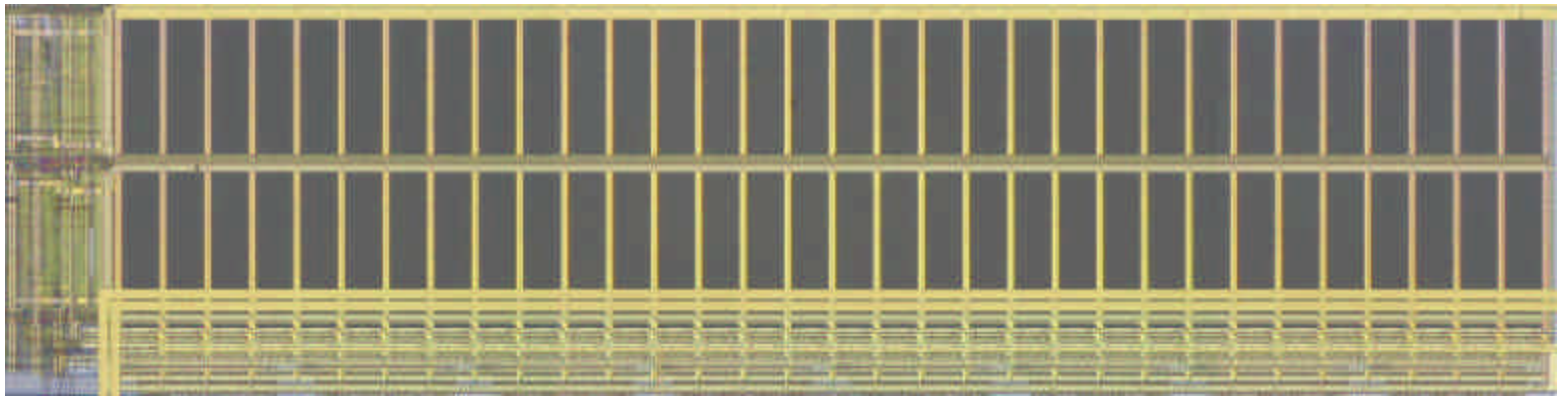
Wasted silicon wastes money!

Mamba



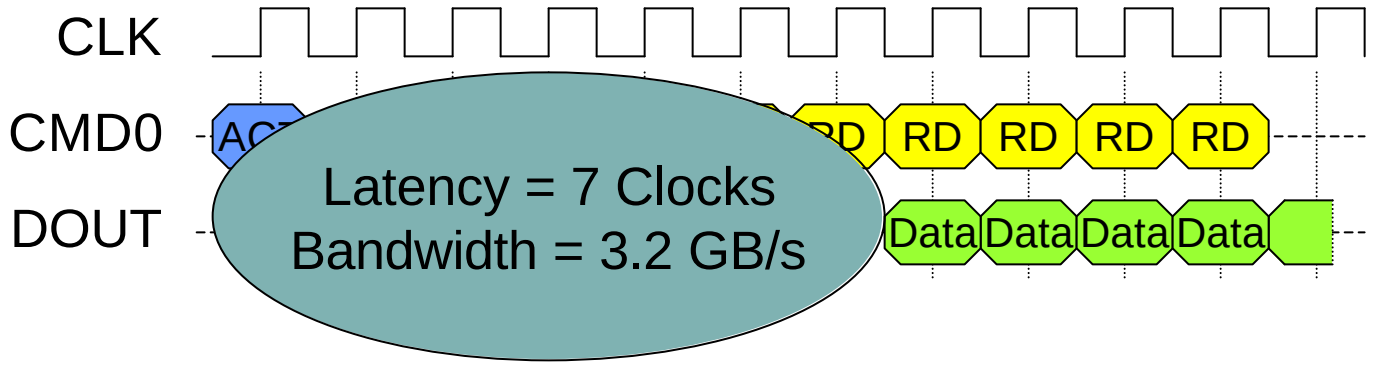
Package: 670BGA

Micron's 1MB eDRAM Core

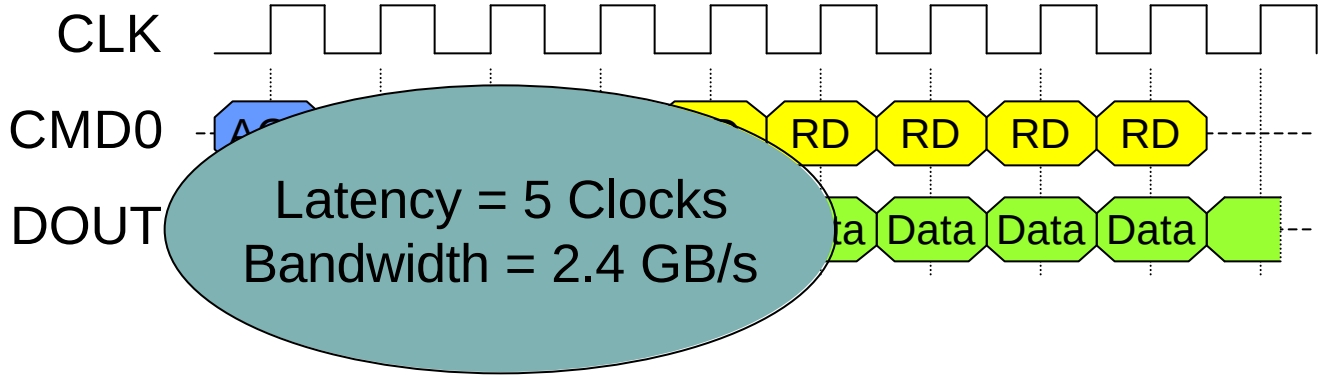


eDRAM Access

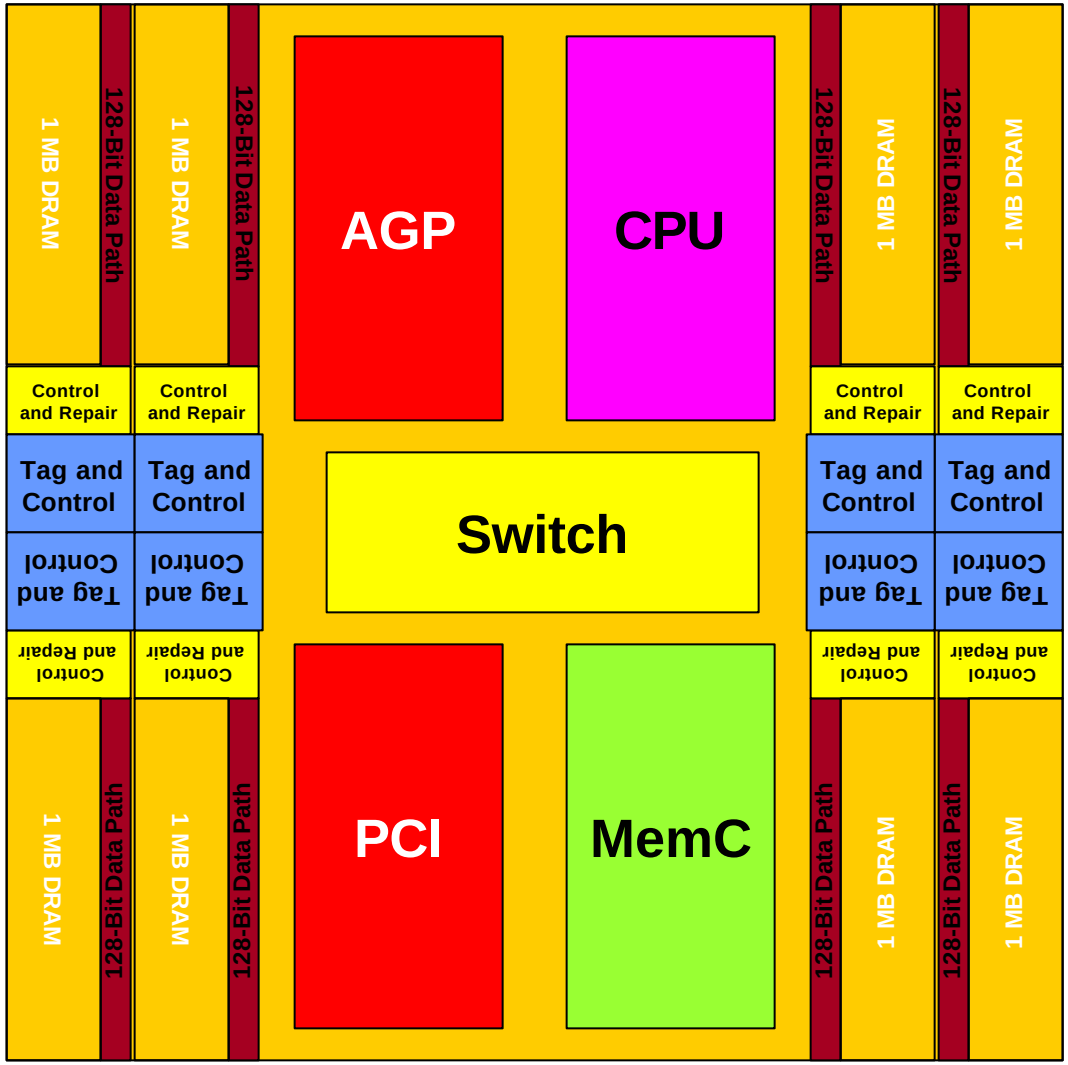
- Standard eDRAM core



- Mamba-enhanced eDRAM core



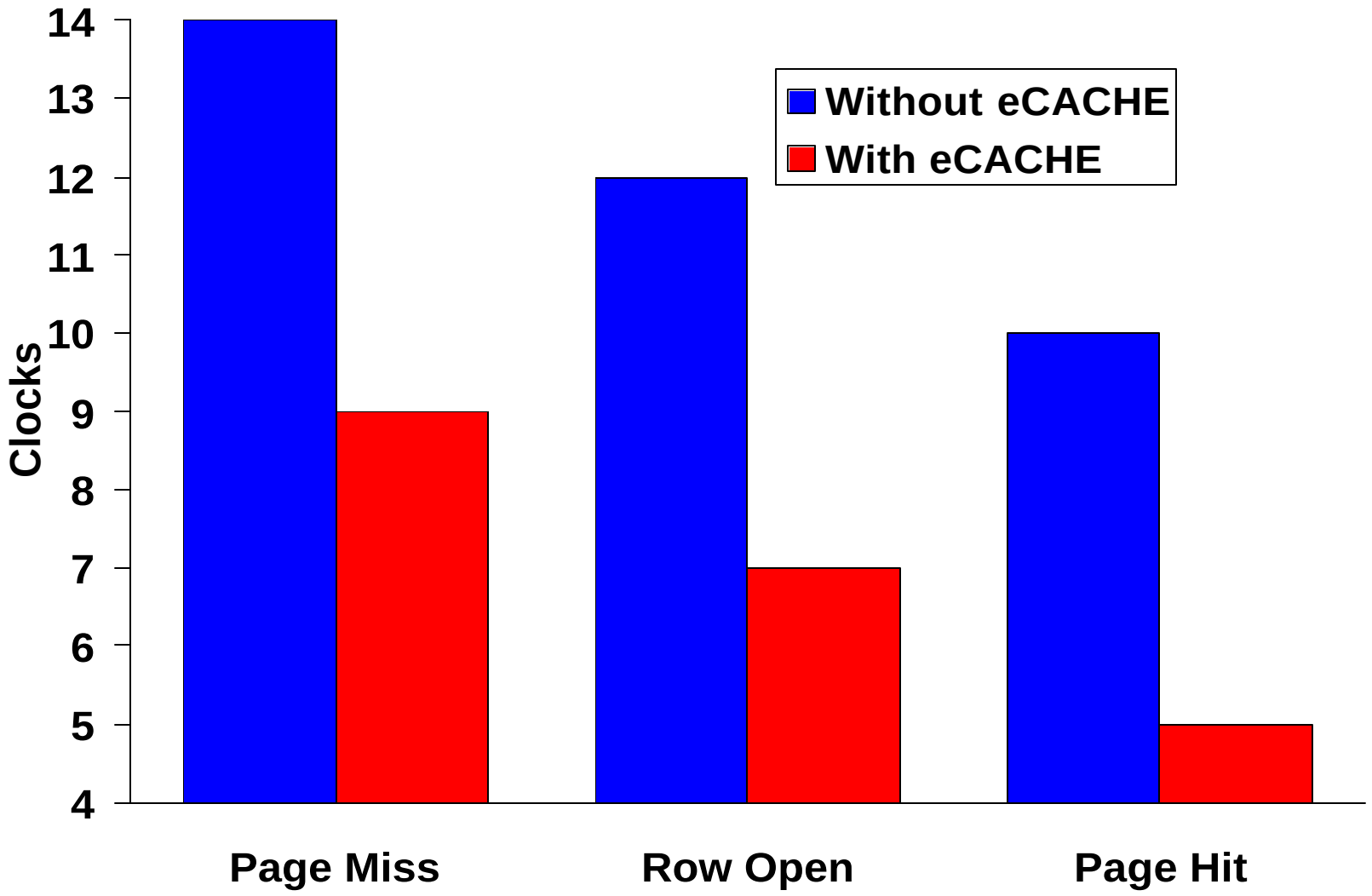
Mamba eCache



eCache Bandwidths

- eDRAM aggregate bandwidth is limited only by die size
- eCache aggregate eDRAM burst bandwidth is over 19 GB/s
- As implemented, it allows simultaneous access to four arrays and four device ports, with a sustainable bandwidth from memory of 9.6 GB/s
- Command, access, refresh, and precharge times can be overlapped, allowing sustained 9.6 GB/s

eCache Latency

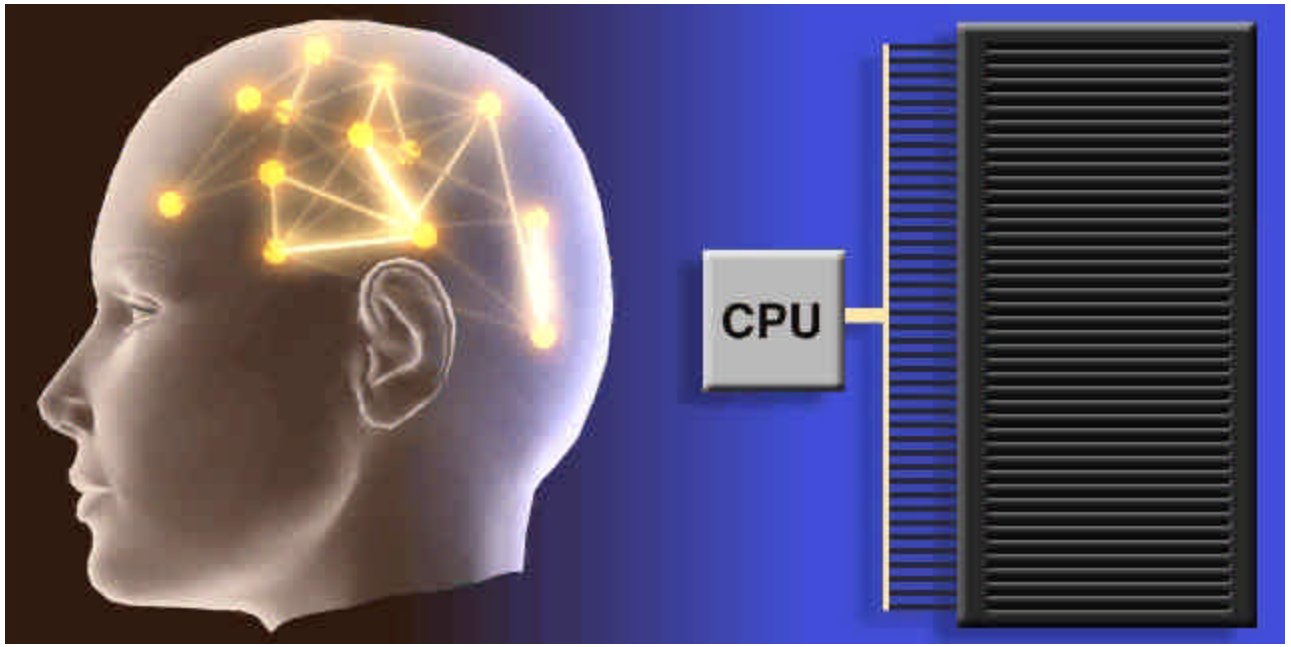


(DRAM shown with 2-2-2 timing, 3-3-3 is worse)

Micron eDRAM eCache

- Embedded DRAM can be built cost effectively
  - Can improve performance both on-chip and off chip
  - Granularity allows size to be tailored to fit application
- Architectural decisions made with eCache allow low latency and high bandwidth
- Core logic architecture allows maximum utilization of eCache

Future Memory?
Smart Memory



Conclusions

- Different solutions for different platforms – divergence, specialization
- The industry is evolutionary – understand it!

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